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BS - Series

Multichannel Bias Supply

- precision voltage source -

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User Manual

Rev. 2.21

BS 1-4, BS 1-10, BS 1-16

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1. General Information and Overview

1.1 Purpose and Description of the Device

BS Series devices provide precise and stable DC voltages up to +/-14V (depending on device version) for biasing purposes. Unlike DC *power* supplies, the outputs currents are limited to small values, and the outputs are optimized for high short and long term stability, low noise and low temperature drift. The device is housed in a standard 19-inch rack-mount case. User control of the device is accomplished by PC control programs, utilizing a standard USB connection (USB 2.0 compatible). The programmed voltages and measured output currents are displayed on the front LCD display.

1.2 Functional Principle and Block Diagram

The following picture displays the internal structure. A USB interface receives commands from a PC, which are translated into output voltages on 8, 10 or 16 channels. Voltages and corresponding output currents are displayed on the front display. In case an output is not able to establish the desired voltage, or if a current overload occurs, indicators on the user interface will signal a malfunction. All outputs can deliver both voltage and current polarities, negative as positive (4-quadrant operation).

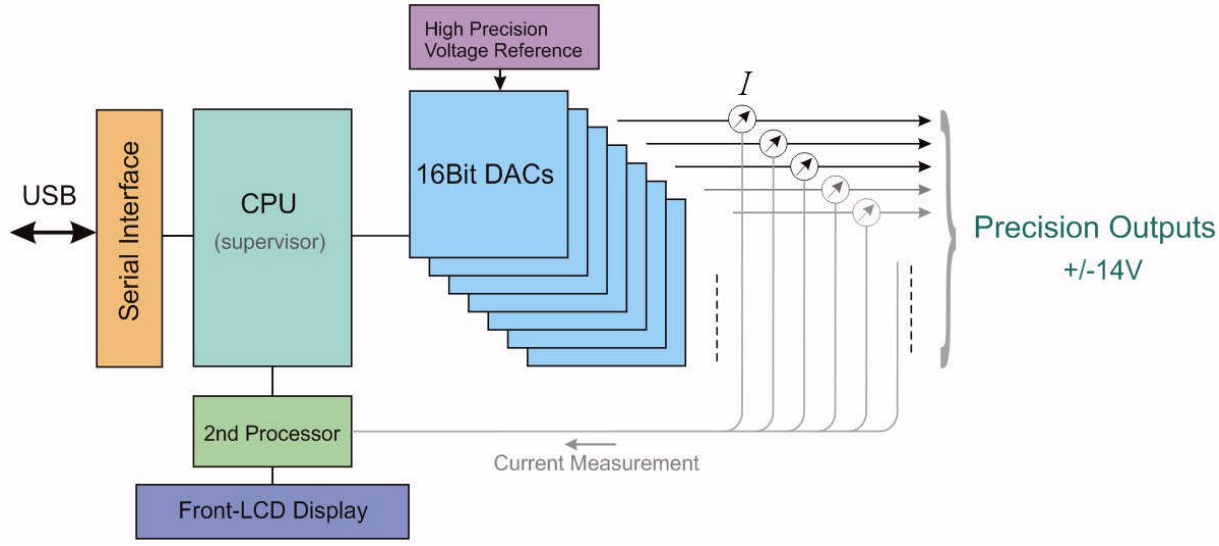


Fig. 1.1: Illustration of internal structure (simplified)

1.3 Device Variety

The following devices are currently members of the BS series device family.
For higher voltage ranging up to 1000V please refer to HV series, see manufacturers homepage.

designation	derivate	description
BS 1-16	-14	16 channel +/-14V supply, 16Bit resolution
	-10	16 channel +/-10V supply, 16Bit resolution
	-5	16 channel +/-5V supply, 16Bit resolution
BS 1-10	-14	10 channel +/-14V supply, 16Bit resolution
	-10	10 channel +/-10V supply, 16Bit resolution
	-5	10 channel +/-5V supply, 16Bit resolution
BS 1-8	-14	8 channel +/-14V supply, 16Bit resolution
	-10	8 channel +/-10V supply, 16Bit resolution
	-5	8 channel +/-5V supply, 16Bit resolution
BS 1-10 cryo		cryogenic amplifier biasing supply +/-5V 8 ch., 2 cryogenic amplifier PID loops
	other variants are available on request	

2. Safety Hints

Observe installation, operation, and safety instructions	Prior to operation, thoroughly review all safety, installation, and operating instructions accompanying this equipment.
Rear side switch turns device completely off	If the device is not in use for a longer time, it is recommended to turn the mains switch at the *rear* side off, otherwise the device will not be completely separated from the mains supply.
This equipment must be connected to earth safety ground	This product is grounded through the grounding conductor of the power cord. To avoid electrical hazard, the grounding conductor must be connected to protective earth ground.
Do not modify the unit	Do not make electrical or mechanical modifications to this unit, which are not authorized by the manufacturer.
Do not operate in wet/damp conditions	To avoid electric shock hazard, do not operate this product in wet or damp conditions. Protect the device from humidity or direct water contact.
Disconnect power before servicing	To avoid electric shock, disconnect the main power by removing the power cord prior to any servicing.
Do not block chassis ventilation openings	Slots and openings in the chassis are provided for ventilation purposes to prevent overheating of the equipment. Case vents should continuously be cleared in order to ensure proper operation and to prevent overheating. If mounted in a rack, please allow 2cm clearance at the top cover with respect to the next device above. By means of software, the internal temperature sensor can be read out. A temperature over 55°C indicates inadequate air ventilation. Additionally a second sensor can be read out in the display's protocol mode (see section 4.1).
Beware of external magnetic fields	As it is common for most electronic devices, external magnetic fields can impair, damage or even destroy a device. A maximum

	external field strength of 10mT is admissible and must never be exceeded. This holds for static as well as alternating fields. If in doubt, check possible external field e.g. with a hall probe before switching the device on. In case an external field strength of 10mT is exceeded, once or permanently, the device may overheat or cause excessive power consumption.
Operate carefully with respect to risk of electrical shock	In case the floating ground input is used, the internally produced voltage adds up to the externally applied. Voltages above +/- $100V_{DC}$ therefore may appear at the outputs which are harmful in case of direct touch with the human body, or which may endanger other sensitive devices.
Routinely cleaning from dust	After long operation, or operation in a dusty environment it is strongly recommended to have the internal parts of the device cleaned by the manufacturer, or an appropriately qualified workshop in order to ensure proper operation and reduce the hazard of overheating.
Only operate with working air fan	The ventilation fan located at the rear side of the device always needs to work to ensure proper cooling. Please refer to section 6.
No outdoor operation	Outdoor operation of the device is not admissible.

3. Installation

3.1. Mechanical and Electrical Installation

Positioning: Sufficient air cooling should be provided to the device. Rack mounting into a standard 19" rack is as well possible as resting the device on a table. Case vents must be cleared (fan inlet and air outlet at rear side), in order to prevent overheating or thermal drifts. If in doubt about the sufficiency of air ventilation, provide a software readout of the internal temperature sensor for regular inspection, e.g. every 2 minutes. Alternatively the temperature of a second sensor can be read by switching the display to the protocol mode (see section 4.1, below).

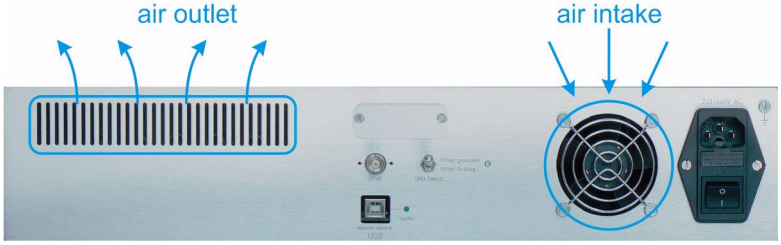


Fig. 3.1 Keep air vents always clear to ensure ventilation

Connecting to mains power:
Connect the device to the mains power supply by using an appropriate power cord, being properly wired and providing a grounded outlet. The power cord must be suited with respect to possible load currents and should be rated to at least 1A current.

Cabling of voltage outputs:
Always provide appropriate cabling to the device, shielded cables are preferable to ensure avoidance of external noise pickup. In case the reference ground is floated always be aware about the potential hazard of high electrical voltages to human beings and sensitive objects of all kind (see also safety hints in section 2).

USB connection:
Use a standard type-A-B connection cable (USB 2.0 standard) to connect the device to the control computer. After connecting to a PC under Windows, the "Found New Hardware Wizard" should open

(see next section for detailed description), regardless if the device is already switched on or not, since the corresponding receiver inside the device is powered by the USB bus itself and therefore autonomous. Cable length can be prolongated using an appropriate USB hub or repeater.

3.2. Software installation

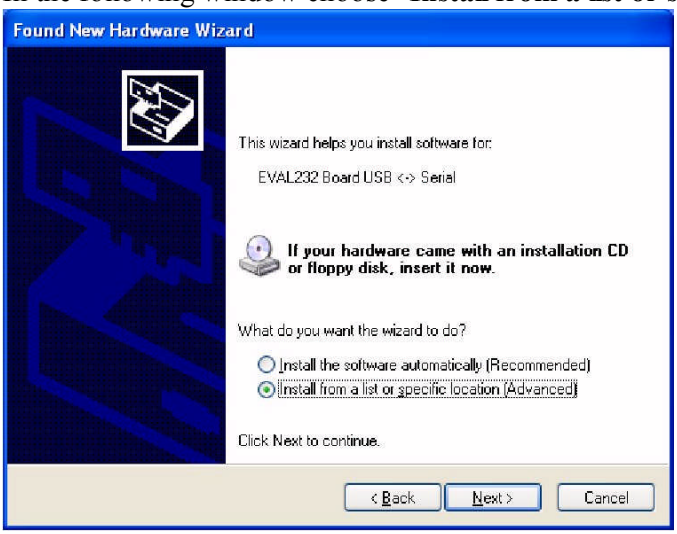
3.2.1 USB-Driver

The device uses the USB bus for connecting to a control PC. After proper cabling of the USB connection (see section before) the "Found New Hardware Wizard" under Windows should open up. Depending on the Windows version allow a few seconds to automatically identify the connected device and install drivers, or follow the described steps below. The automatic or manual installation will install the USB-CDM drivers from FTDI Ltd., which is the manufacturer of the USB bus interface circuitry.
The supplied installation CD provides suitable drivers for operation under Windows XP. Latest drivers, also for different other operating systems (Linux, Mac OS, other Windows versions) can be downloaded from http://www.ftdichip.com/FTDrivers.htm. Note that the device appears as a RS232-controlled device, communicating with standard settings (9600 Baud, 8N1 protocol, no handshake) unless special settings are used (see appendix).

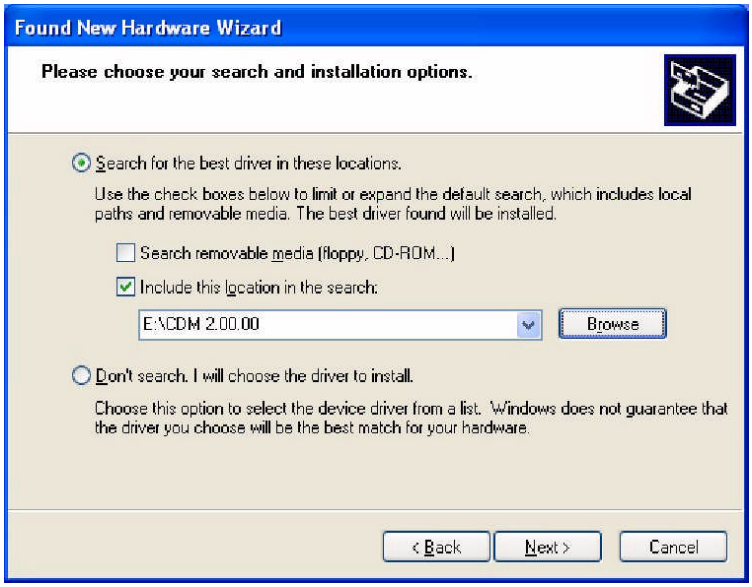
Execute the following steps after start of the "Found New Hardware Wizard":

Found New Hardware Wizard
Welcome to the Found New Hardware Wizard
Windows will search for current and updated software by looking on your computer, on the hardware installation CD, or on the Windows Update Web site (with your permission).
Read our privacy policy
Can Windows connect to Windows Update to search for software?
Yes, this time only
Yes, now and every time I connect a device
No, not this time
Click Next to continue.
< Back
Next >
Cancel

In this screen activate the last button "**No, not this time**" and continue with "**Next**".
In the following window choose "**Install from a list or specific location**" => "**Next**"


Found New Hardware Wizard
This wizard helps you install software for:
EVAL232 Board USB <-> Serial
If your hardware came with an installation CD or floppy disk, insert it now.
What do you want the wizard to do?
Install the software automatically (Recommended)
Install from a list or specific location (Advanced)
Click Next to continue.
< Back
Next >
Cancel

Afterwards choose “Search for driver in these locations” and “Include this location in the search”. Browse now to the provided Installation CD and select the appropriate path with the USB drivers.

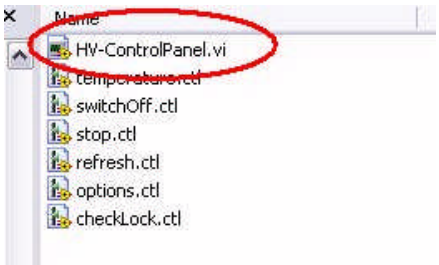

Found New Hardware Wizard
Please choose your search and installation options.
Search for the best driver in these locations.
Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.
Search removable media (floppy, CD-ROM...)
Include this location in the search:
E:\CDM 2.00.00
Browse
Don't search. I will choose the driver to install.
Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.
< Back
Next >
Cancel

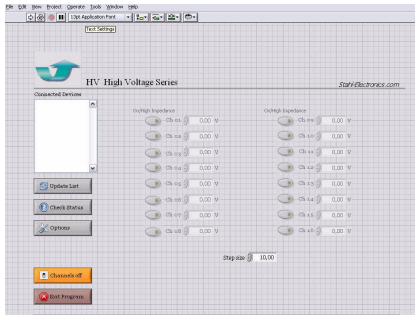
Click “OK” and “Finish” to complete the first driver installation.

After a few seconds the first window will show up **again** (“Found New Hardware Wizard”). This is because the drivers come in two separate parts, which **both** have to be installed. Go through the installation steps in the same way as before. After completion, the USB drivers are ready for use and Windows indicates this by showing “Device Ready” (or similar) in the lower right screen corner for a couple of seconds.
Windows usually recommends to restart Windows now, but normally one can skip this point. Nevertheless note that the PC should be restarted *before* installing any other piece of hardware or software.

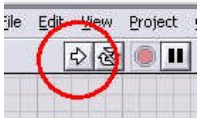
3.2.2 LabVIEW™ control program

A LabVIEW™ based control program is used to operate the device. Its operation is described in section 4.2. Its installation assumes that the LabVIEW™ development environment in Version 8.2 or higher is available on the target PC (if this is not the case, please see below). Copy the path containing the LabVIEW™ source code VI’s from the installation CD to a proper place of your choice on a local drive. To start it, double-clicking on the file





“HV-ControlPanel.vi” in the path “ui” (“User Interface”) the control panel for HV and BS Series devices will open, which can immediately be started by clicking on the



start-arrow in the upper left corner.

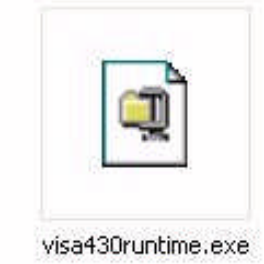
In case that the LabVIEW™ development software in version 8.2 or higher is **not** available on the PC, which controls the device, there is a second option. The "LabVIEW™ run time engine" can be installed from the installation CD and the application program (containing the control software for the HV-Series and BS-Series devices) can be run subsequently as stand-alone program. In this case modifications of the control software or implementation in own programs are not possible but the completed software can be run unchanged in the version as it is. Please contact manufacturer for more details and possibilities, in case any changes of the program are desired.
To install, launch the **LabVIEW™ Runtime Installer Wizard**, and follow the instructions.

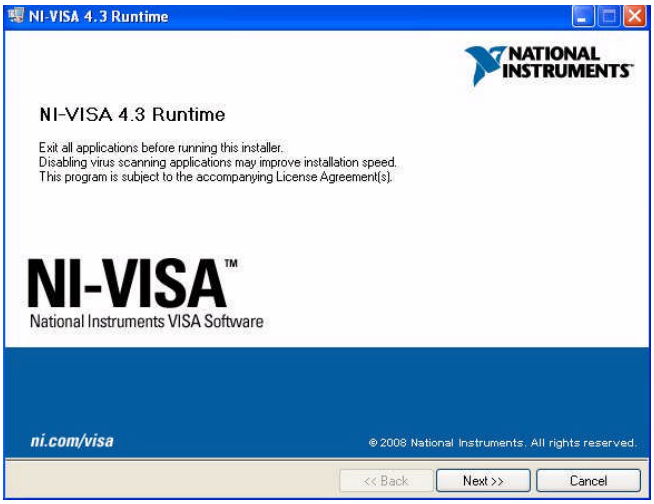
RuntimeEngine File Icon

NI LabVIEW 8.2 Runtime Engine
NI LabVIEW 8.2 Runtime Engine
Exit all programs before running this Setup.
Disabling virus scanning utilities may improve installation speed.
This program is subject to the accompanying License Agreement(s).
LabVIEW 8.20
20th Anniversary Edition
© 2006 National Instruments. All rights reserved.
<< Back
Next >>
Cancel

You will be requested to choose an installation directory and location for unzipping the required files.

Furthermore (in case not installed before) the **National Instruments VISA drivers** need to be





installed, which enable the LabVIEW™ software easy access to the PCs hardware resources.
After completion of these two installations, the control program can be run in the executable file version without having the LabVIEW™ development environment installed.

3.2.3 Self-written Code

In order to access the device by self-written program code, simple commands in ASCII style can be used. These are described in the appandix (see end of this manual) and can be sent though own programs e.g. like C++, BASIC or Pascal/Delphi dialects. The physical connection to the device needs to be established beforehand, like described above, section 3.2.1 .

4. Operation and Control Elements

4.1 Elements on the front plate

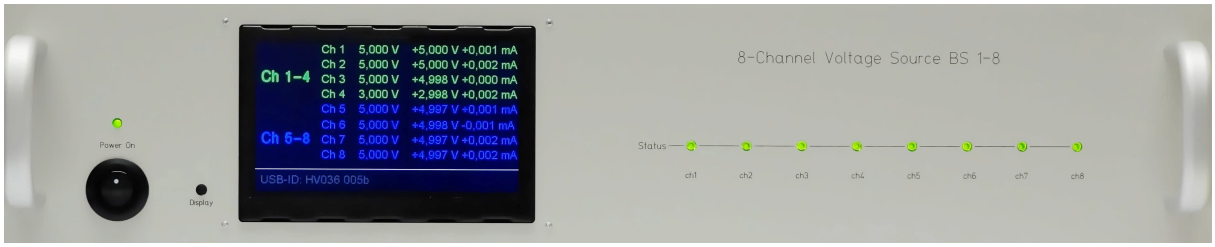


Fig. 4.1: Front side of device

The device is powered up after flipping the power-switch on the rear-side and also the **mains-button** on the front plate. The **Power-on-LED** (green) indicates proper operation of the internal supply circuitry. If the device is not in use, it is recommended to use the rear side mains switch to cut it completely off from mains supply. This will minimize all supply currents, and is also recommended for safety reasons (e.g. overvoltages occasionally occurring on the mains supply line).

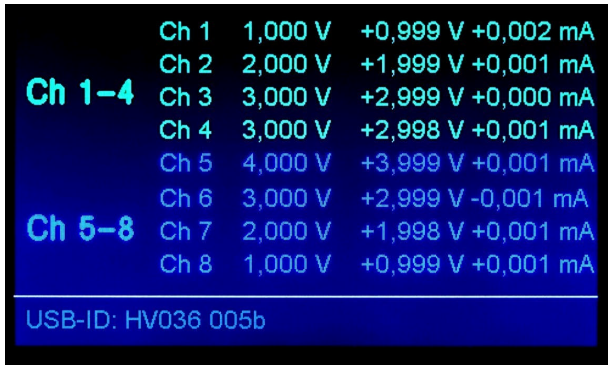


Fig.4.2:
Pressing the "LCD-display key" toggles the display view between two possible states: Protocol Mode (left) and Voltage Mode (right). As an example the right pictures shows an 8-channel BS-device. Screen appearance differs slightly depending on device variant.

Fig. 4.3:
Mains-button , power-on LED and LCD-display key are on the left side of the front plate.

The **LCD display** shows information about received commands and the latest voltage settings for the output channels. It can be run in two modes: In the "Protocol Mode" all commands, which are received via the USB connection are listed, subsequently one after another. Also the device's internal temperature, the total operating hours, device type and USB identifier string are shown. The latter string is sent on request to an interrogating PC in order to state the devices identity. In the "Voltage Mode" all programmed voltages are listed and furthermore all corresponding output voltages and currents, which are measured at the output lines. Please note that the output accuracy surpasses the accuracy of the read-back values shown in the right part of the display. Please see accuracy specifications in section 7 for details. The two display modes are toggled (alternated) by pressing the **LCD-display key** on the front plate.
The LCD display enters a power-save mode after roughly 60 minutes using dimmed backlight intensity. Any press on the LCD-display key reactivates the full backlight again.
The programmed voltages are provided on BNC, SMA or Sub-D output connectors on the front or rear plate, depending on the chosen option. Please note that the floating GND option can shift (offset) the output voltages by using the offset input at rear side. The display shows only the internally created voltages, and does not take into account any externally added offset voltage.

In case an overcurrent condition occurs (threshold is normally set at a current limit value of about 7.9mA) this is indicated by highlighting the value of electrical current in the corresponding display line (see picture below). In devices with LED status indicators on the front plate, the corresponding LED will turn red. These LED indicators are normally green and only become red in case of an internal malfunction or in case of an output current exceeding the set limit. Please note that the LED indicators are only mounted in devices with no other elements on the right half of the front plate. Their status is also displayed in the window of the device control program (see section below) and can be interrogated by a dedicated software command as well.

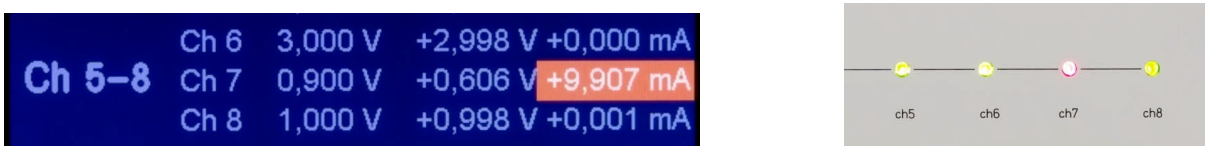


Fig. 4.4: In case an output current exceeds the defined limit, the corresponding current value is highlighted in red. If installed, additional LED indicators show each channels status. E.g. ch7 is ”red”, indicating an exemption.

4.2 Control Software

After starting the LabVIEW™ main VI or application program the following user surface will appear, which can be operated in a mostly intuitive style. Controls for 8, 10 or 16 channels, depending on device version are visible. By modifying the open souerce code the user can easily change the appearance and functionality.

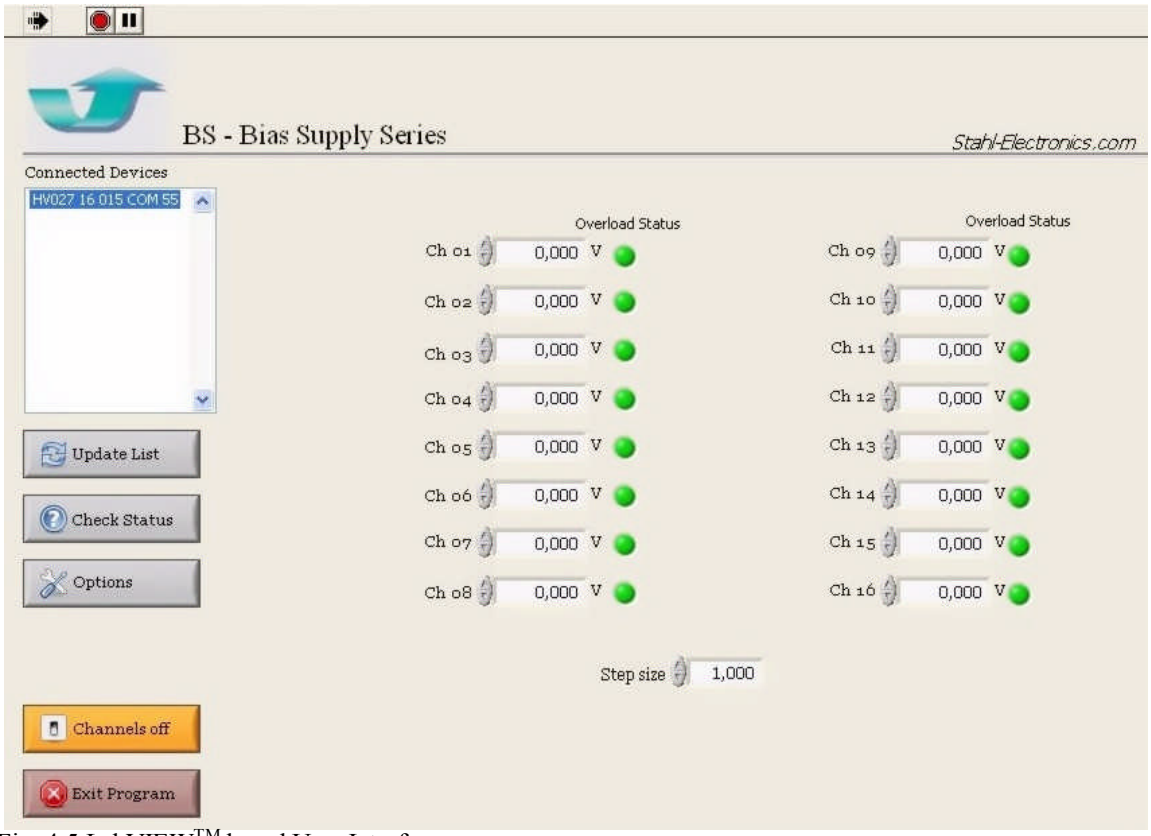
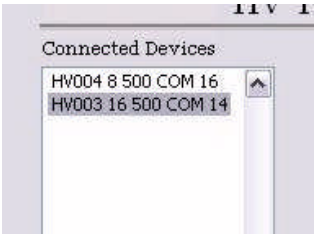


Fig. 4.5 LabVIEW™ based User Interface

While starting up, a list of connected devices (upper left corner) will be updated and the program will list all recognized HV- and BS-Series devices inside the window. Please note, that before taking any action the user should click once on a device in the list to select this device for further operation.



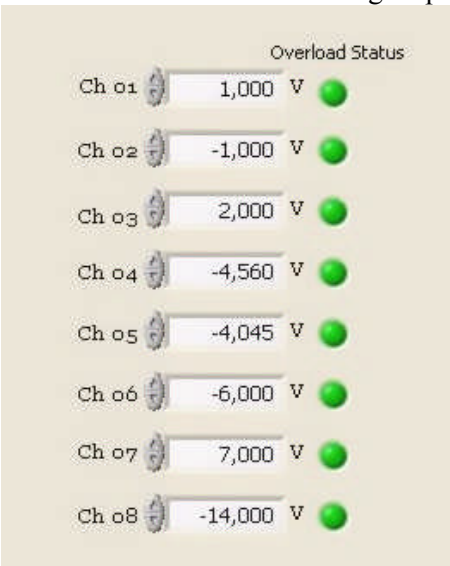
picture shows a list with two recognized devices inside the displayed list.

The information about the listed devices shows:

- device serial number (e.g.: HV021, for a device with serial number 021)
- the number of available channels on that specific device
- the voltage rating (e.g. 10V), including overrange
- the COM port number, under which the device will be accessible in Microsoft Windows from the PC.

Note, that the driver software on the PC will enumerate detected USB devices automatically. This COM port number may vary from PC to PC and does not depend on the connected device itself.
If a new device is connected while the program is already running, the list can be forced any time to be updated by pressing the

button.
Next right to the list of connected devices the user can set the voltages of each channel in the numerical control field, either manually by entering numbers or by clicking on the up/down arrows. A step size can be defined in the control field underneath the voltage input controls.



At right hand side besides the numerical control field for the voltages, the "Overload Status Indicators" appear. They indicate the status of the circuitry for every channel. As long as the set voltage can be held, the indicator is green. If the pre-defined over-current value of +/-8.6mA is exceeded, it will lighten up red. Depending on LabVIEW settings the control program reads the actual status over the USB bus roughly once per second. A forced and immediate status check is possible, if the user clicks on the

button.

By pressing the Options Button

, the user can manually read the device's internal temperature in the subsequent window or enter manually commands to the device (for advanced users, see also the list of commands in the appendix).

4.3 Output Characteristics

General properties

The device features stable bipolar low-current DC voltage outputs with low noise, ripple and low temperature drifts. However, heavy external loads should be avoided, which might exceed the device's nominal output current of 10mA on a longer time scale (minutes, hours).
The outputs feature an internal resolution of 16 Bits. This translates into effectively about 1mV programming resolution in case of a +/-14V output range or about 150µV in case of a +/-5V range.
The output reacts on voltage change commands after a delay (see appendix) depending on the speed mode and with an analog signal rise time (10%-90%) of typically 20µs.

Output accuracy, fluctuations and loads

Precision components ensure a very good basic accuracy and very low long-term drift, both on a 10^{-4} to 10^{-5} level. Intrinsic short term stability is on a level of several µVolts, corresponding to only a few ppm's (parts per million) with respect to the full voltage span. For details about 24h-fluctuations see also technical data in section 7 and fluctuation data in section 8. The traces in section 8 were taken at a +/-14V device. Devices featuring other output voltages behave similar, fluctuations essentially scale with the output voltage span.
All outputs feature protection resistors of 2.2 Ohms serially to the internal output amplifiers (50Ω in case of the PID version), which will cause a voltage drop as soon as current is drawn from any output. Please take into account that voltage drop (according to Ohms law) for operation with considerable load currents or for high precision measurements. Heavy capacitive loads (>2µF) should be avoided for stability reasons, especially in conjunction with very long cabling (> 20m). In cases where higher capacitive loads or longer cabling is required, the addition of about 20 Ohms in each line will ensure better stability. You may also contact manufacturer in cases with longer cabling or heavier loads in order to adapt the output properties accordingly.

Short cuts or other heavy loads at the outputs

Generally all outputs are short-cut proof, with respect to GND-short cuts or short cuts to any voltage between the specified min./max. voltage. Nevertheless shortcuts represent a heavy thermal load on the internal output stages and may impair their life expectance, in case present for longer times. This holds especially, when the optional floating offset input is used (see chapter below), which may increase the current flowing in case of a short cut event considerably. Externally applied offsets larger than +/-5 V therefore may damage the outputs in case of a short cut event, due to excessive thermal load on the output stages.
It is recommended to check the status indicators on a regular base, e.g. latest every 5 seconds by software means (see appendix for software commands). In case of an overcurrent exemption the corresponding indicator will become "red" indicating a problem and a countermeasure like putting all relevant voltages to safe values is recommended.

5. Floating Ground Option

Using the Floating Ground Option

In case the option for floating ground is installed, the user has the possibility to float the reference ground to a certain amount with respect to the case of the device and shielding ground of the attached cables. Please note that the voltage settings given from the control program refer always to the local reference ground. The *absolute* value of voltage at any output with respect to the case ground is therefore given by the *sum* of the externally applied voltage at the floating ground input and the programmed value, as mentioned above. The device does not measure the externally applied voltage explicitly. Any voltage on the "floating GND/Offset GND" input places a common offset to all of the voltage values, which are programmed by the user. Voltages within the maximum range of up to +/- 100V are applicable to the floating ground input.

Fig. 5.1 Rear side view: The offset input connector is located above the USB plug.
In case no external offset is applied, the user should switch the
GND selector switch to "Offset grounded".

Please note that if there is no intention to commonly shift all output values by using the Offset-GND input, the respective BNC-plug must be shorted (with a short-cut plug), or the corresponding selector switch changed to position "offset grounded" (see picture above) in order to force the added voltage to be zero. In case there is no such termination, correct functionality of the device is not guaranteed. This GND selector switch is for safety reasons mechanically locked and can be changed only by carefully pulling the lever handle (unlocking) before moving.
Care has to be taken in case the reference ground is floated accidentally, since high voltages might charge up by even small parasitic currents. These high voltages (e.g. in setups with ion/electron beams) may easily damage this device and all connected devices.

6. Maintenance

The BS and HV Series Voltage Sources are designed for years of reliable operation. Under normal operating conditions, it should not require electrical maintenance, but routinely cleaning of dust, and in longer time intervals, replacement of rear fan (see below). If any further question should arise, please contact the manufacturer.

Routine cleaning

All ventilation openings – top, bottom, sides, and rear panel – should be checked periodically and kept free of dust and other obstructions. A vacuum cleaner may be used to clean these vents when the unit is powered off. Do not use compressed air to clear the vents. The front panel may be cleaned periodically with a clean cloth and alcohol solution, when the unit is powered off. It is recommended to send the device to the manufacturer routinely in 5-year intervals for internal cleaning from dust. Visual inspection of the degree of internal pollution and accumulated dirt is possible, but should be carried out by qualified personnel only. In this case wait at least 5min after switching power off, and

disconnecting all external high voltage lines and the mains cable. After removing the 6 screws of the upper lid, the latter is removable and allows a look on the internal electronics boards. Very careful cleaning by qualified personnel and using a small miniature vacuum cleaner is admissible.

Calibration

Under normal operating conditions, the HV/BS Series Voltage Sources will not require regular calibration. However, they can be returned to factory for complete electrical and mechanical inspection and calibration purposes. Also, if required, a certificate can be issued for traceability. Contact manufacturer for further information.

Fan life time and temperature monitoring

The ventilation fan at the rear side of the housing is a part which shows deterioration and finally failure in time. Exchange of this part is recommended after latest 50.000 hours of operation. Please contact manufacturer for replacement after long term operation. Complete failure may severely impair the accuracy specifications due to overheating of the device. Temperature fuses and other protection measures ensure a certain degree of safety against fire hazard in this case. Nevertheless, it is strongly recommended to read out regularly the device's temperature by software means in order to monitor the internal temperature and therefore to ensure avoidance of damage to the device. In the "protocol mode" of the front display the user can also visually check the internal temperature. Values above 55 degree Celsius indicate a possible problem.

Fan speed monitoring

A fan speed monitoring circuit routinely checks the fan rotation speed and gives an acoustic warning signal (intermittent sound) in case of low rotation speed and in case of a fatal failure (permanent warning sound). This feature is available in all BS devices after production date dec. 2011. A few seconds after turning the device on the warning sounder is shortly active to demonstrate its proper operation.

7. Special Functions, Cryo Supplies, PID Loop

The BS Series supplies can be equipped with additional functions, which ease their use as cryogenic biasing supplies, e.g. for Gallium-Arsenide based low temperature amplifiers. Two banks of 5 channels each are provided in a BS 1-10 device.

Output channel assignment:

If connected to a GaAs cryogenic preamplifier, one may choose to use the subsequent channel number assignment, even though this choice is not mandatory (except a PID loop is used, see chapter 7.2):

ch1 **Gate 1 first cryo stage**
ch2 **Gate 2 first cryo stage**
ch3 **Gate 1 second cryo stage**
ch4 **Gate 2 second cryo stage or Drain supply**
ch5 **Drain supply of one or two stages**

and ch6 to 10 connected in the way like ch 1 to 5.

Note: The ch5/10-functionality is different in case of an installed PID loop (see chapter 7.2).

7.1 Manual Voltage Control

If the corresponding option is installed, one may choose to user either an external PC to control the output voltages (remote-mode) or define them by adjusting a potentiometer on the front plate (manual mode). A manual switch on each channel defines the used mode ("remote" or "manual mode").

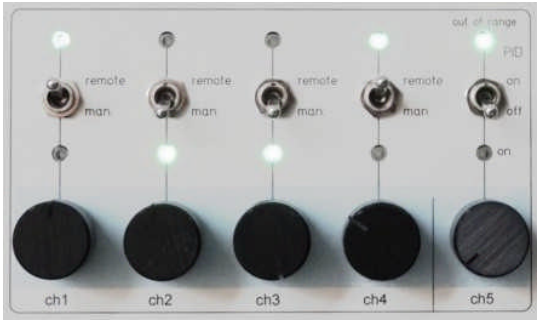


Figure 7.1: Individual switches for each channel allow to choose between remote control and manual control of an output voltage.

7.2 PID Loop for Cryo Amplifiers

A PID Loop for cryogenic amplifiers may be implemented, which can be used to achieve stabilization of cryogenic (e.g. 4.2K) FET-based amplifiers. This loop assumes an inverting amplifier stage like shown in the subsequent figure. An Ion trap was assumed as signal source for example.

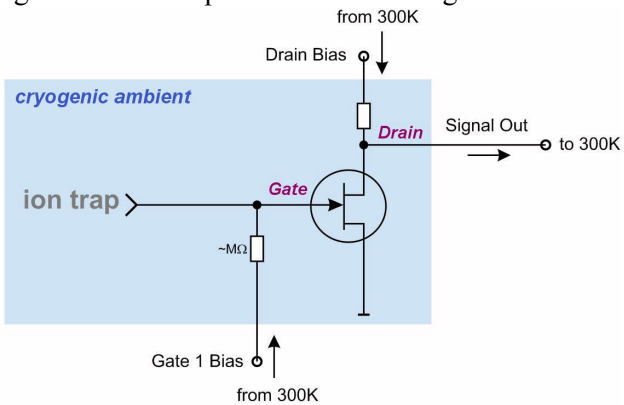


Figure 7.2: schematic diagram of a FET-based cryogenic amplifier

Well-know problems related to cryogenic amplifiers are temporal and thermal drifts, arising from small temperature changes in a cryogenic environment. In setups with several amplifiers operating at the same time the biasing adjustment can be highly complex since the adjustment of one channel may affect neighbouring ones by thermal coupling or parasitic DC-currents on the GND-line.
An effective countermeasure is the use of an automatic stabilization loop, which keeps the Drain DC-voltage of individual FETs, and thus their Drain current and power dissipation constant. Such loops are provided in the BS series supply in case the corresponding option is chosen. 2 loops are implemented per device. The subsequent figure shows the wiring principle.

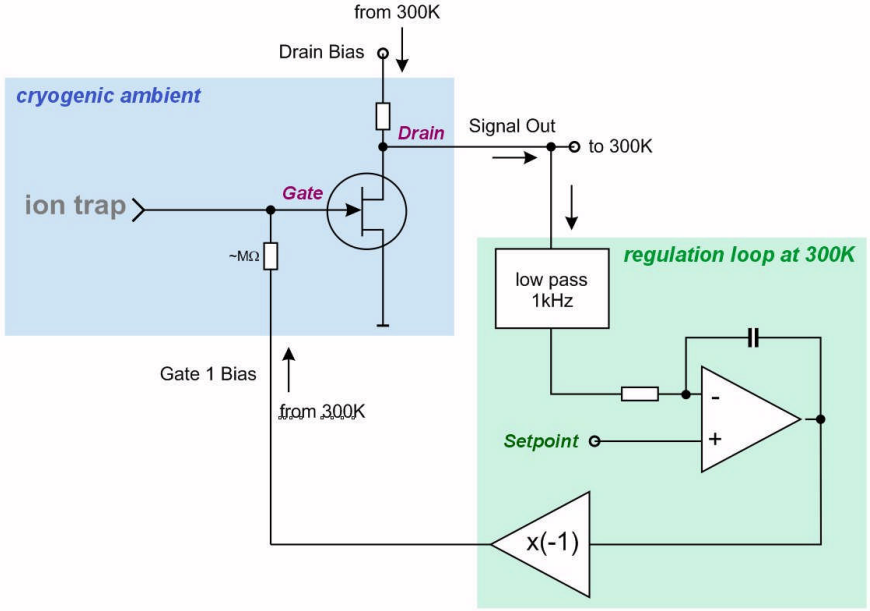


Figure 7.3: scheme of a cryogenic amplifier and a slow feedback loop to maintain Drain voltage stability.

The used circuit employs operational amplifiers to generate the FET Gate 1 control voltage (channels 1 and 6 of the BS supplies). The DC level of the Drain output voltage is measured (PID input at rear side) and compared with a setpoint voltage. This setpoint is manually adjusted by the channel 5 (and 10) potentiometer on the front plate. It can be measured at the corresponding BNC output sockets at the rear side (5 and 10). The voltage difference between setpoint and read-back value is translated into a correction voltage and fed into the Gate-voltage to correct the biasing of the amplifier. This closed loop keeps the Drain voltage constant at the setpoint level (only the DC part is used in order not to influence AC signals of interest). The correction sensitivity has a value of approx. 10Volts/second per Volt deviation of setpoint-Drain difference, representing the integral ("I") part of a PID loop. E.g. at a voltage difference of 1 Volt (setpoint to actual voltage), the Gate 1 voltage will be adapted with an initial slope of 10V/second until the setpoint value is reached.
The position of the PID-switch (on front plate at channels 5 or 10 respectively) is decisive for the function of channel 1 (or 6):

In case the PID-switch is **activated** (like shown in the photo beside) then the internal PID loop regulates the output voltages on channel 1 (or 6 respectively) at the rear side. Changes on the potentiometer on channel 1 (or 6) or a command on channels 1 or 6 have no effect at all. Only the setpoint determined by the potentiometer at channel 5 (or 10) and the measured Drain output voltage on the PID input (rear side) causes changes of the channel 1 (or 6) output.
In case the PID-switch is **not activated** the internal PID loop is not active and the output voltages available on the rear side are defined in the normal way by the potentiometer (in manual mode) or by the remotely-controlled value (remote-mode) respectively. The green "range ok" indicator lightens up, if the PID-loop correction voltage (outputs 1 and 6) resides within a voltage range of -2.8V to +0.25V and becomes dark, otherwise.

figure 7.4: The position of the PID-switch activates/deactivates the internal PID loop.

The subsequent picture shows an example of the numbers seen in case of the PID usage (PID loop 1, affecting channels 1, 4 and 5). In this case channel 4 was used as Drain supply voltage, for example set to about 3.95V (white circle in screen shot below). The PID loop was activated with the PID-switch and the set point of Drain output voltage set to 1.515V with the potentiometer below the PID-switch. The read back value of the potentiometer setting is shown in the channel 5 reading, marked with green circle below in fig. 7.5. In order to hold this set point value, the loop regulated the gate voltage to -1.829V (red circle in fig. 7.5). The correct functionality of the loop can be monitored by checking the read back value of the loop voltage (being applied to the PID input at rear side), e.g. 1,502V in this example (yellow circle), which should be equal to the set point, and is indicated also by green LED light above the PID switch.

fig . 7.5 Screen shot photograph using the PID loop 1.

7.3 Output Voltage Limitation

For safety reasons the BS devices intended for supplying cryogenic electronics are equipped with a possibility, which allows the user to set limits to the output voltages. These limits apply regardless whether the manual or PC-controlled mode is chosen. The voltage limits are set using conventional potentiometers. In order to access them one has to open the device lid. Behind the front plate there are 20 variable resistors, which are adjusted with a normal screwdriver.

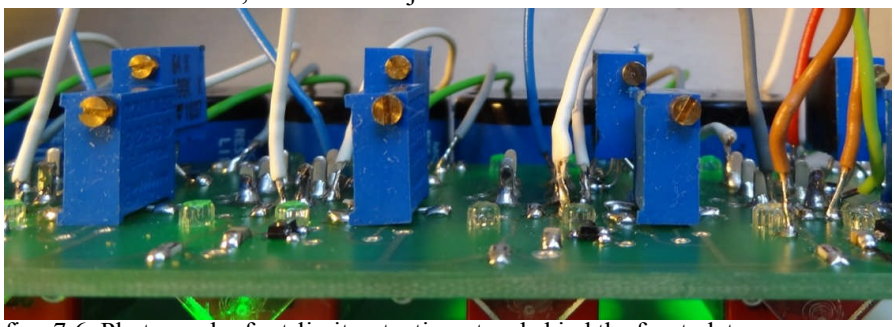


fig . 7.6 Photograph of set-limit potentiometers behind the front plate.

The upper row of potentiometers defines the maximum (normally i.e. positive) value of output voltage, the lower row defines the most negative voltage. Assignment to channel numbers is from left to right from 1 to 10, as it is intuitively clear. In order to adjust a potentiometer, let's say e.g. an upper one, one may set the most positive voltage (remotely or manually) and turn the adjustment screw until the output shows the desired maximum voltage. Proceed with the negative limits accordingly. Please note that if the output voltage approaches the set limit, there is a transition region of about 0,4V magnitude, during which the actual voltage will increasingly deviate from the set value. This represents a "smooth" transition from the set voltage to the limiting value.

8. Specifications

Output Specifications				
Output Voltage Range	Version +/-5V +/-10V +/-14V	depending on version: single fixed range +/-5V to +/-14V, bipolar Note, that 1V of overrange is provided in some devices, e.g. a +/-14V device actually delivers (at low output current) up to +/-15V		
Number of Outputs		8, 10, or 16 output lines, depending on device configuration		
Output Connectors		BNC sockets (standard), others on request		
Output Current	per output	+/-10mA (4-quadrant operation, $\lvert U_{OUT} \rvert$ < 10mA) Overload-indication above +/-8.6mA		
Output Reference Ground		All outputs share a common GND, which can be floated up to +/-100V vs. case ground.		
Output resistance		50 Ohm +/-3% , I < 2mA		
Accuracy				
		typical error	maximum error	typical drift
% of Setting		0.014%	0.02%	0.001% per day
Offset error		±0.9mV	±1.8mV	±0.05mV per day
Temperature drift related to Span related to Offset		 5ppm/K 15µV/K		
Output Fluctuations				
		typical	maximum	conditions
Ripple (50Hz, 100Hz)		< 28µV rms	36µV rms	no output current
Noise, 10kHz…10MHz		≤ 0.5mV rms		
Short/Mid Term Fluctuations @ output voltage 10V, any channel vs. GND Short Term 1 day		 21µV pp 80µV pp	 45µV pp 150µV pp	 observation period 100s sampling interval 1s observation period 24h sampling interval 1s
Channel separation		1.2ppm	2ppm	static channel crosstalk, no output current drawn
Front Plate LCD Screen, Digital Amperemeter and Voltmeter				
Range		+/-20V and +/-10mA Full Scale		
Accuracy:		typical	maximum	
Scale error		0.5%	1%	
Offset error		50mV or 1µA	75mV or 4µA	
Fluctuations		0.1%	0.3%	observation interval ΔT = 10s
Remote Control / Communication				
Remote Connection		USB 2.0 compatible connection to PCs, galvanic isolation provided. The device acts as RS232-controlled device, communicating with standard settings (9600 Baud, 8N1 protocol, no handshake) or in fast-mode (factory ordering option) with parameters 115200 Baud, 8N1 protocol, no handshake. Remark: '8N1' = **8** data bits, **n**o parity check, **1** stop bit.		
USB Isolation Rating		max. +/-300V vs. case GND		

Command Language	clear ASCII code command codes see Appendix
Device Response Time	see Appendix
Software Support	USB drivers are required. Free LabVIEW™ 8.2 based user surface and executable program is provided
Power Supply	
AC Supply Rating	AC input voltage 230V_{AC} at 50Hz, EMI/RFI-filtered. Fuse: medium fast blow 1A
Power Consumption	typ. 14.4W
Environmental Conditions	
Storage Temperature	-55C° to +105C°.
Magnetic Field	max. 10 mT admissible
Operating Humidity & Temperature	non-condensing humidity, temperatures between +10°C and +40°C
Miscellaneous	
Fan	life time typ. 50'000 to 100'000 hours; acoustic warning in case of failure and low speed, this feature is implemented in devices of production date after December 2011.
Case dimensions	standard rack mount 19.00" wide x 10" deep. Front-panel mounting holes are configured for M6 rack bolts.
Weight	approximately 3.0 kg, configuration dependent

9. Fluctuation Data

Output voltage stability at selected voltages over time periods of seconds, minutes and hours.

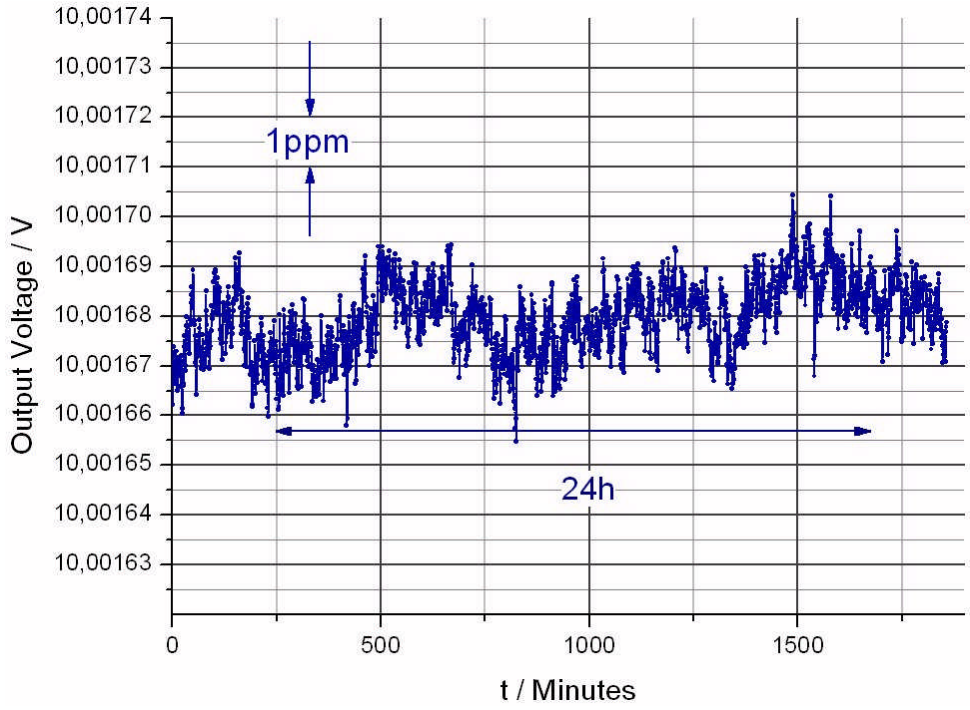


Fig. 9.1: This figure illustrates the stability of an output channel at +10V over a 1-day interval. Measurement device was a Fluke 8846A multimeter, 30sec. averaging per data point. The room temperature has been determined to be constant within +/-0.7K during the measurement.

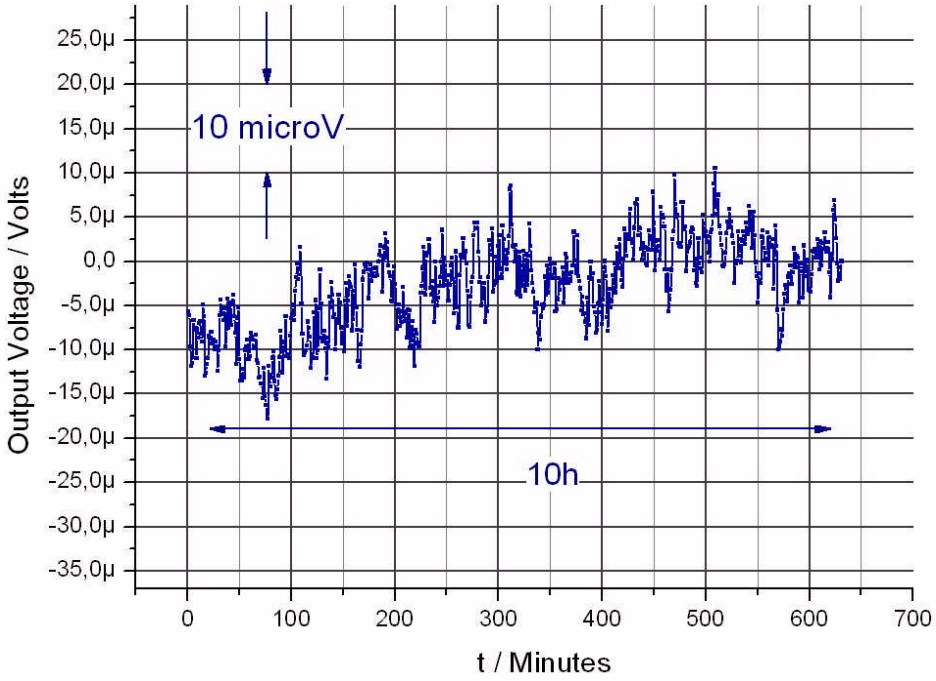


Fig. 9.2: This figure shows a typical offset behaviour over a 10-hour interval (output voltage nominally at zero volts). Measurement device was a Fluke 8846A multimeter, 30sec. averaging per data point. Ambient temperature has been determined to be constant within +/-0.7K.

Fluctuation Data (continued)

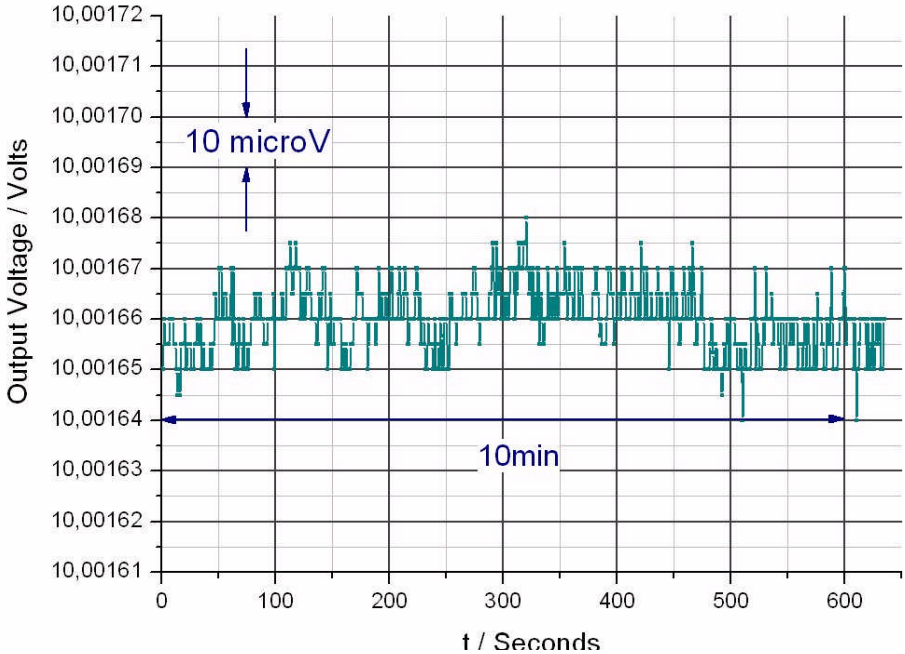


Fig. 9.3: This figure illustrates the short term stability of an output channel at +10V over a 10-minute interval. Measurement device was a Fluke 8846A multimeter, 0.5sec. averaging per data point. One measurement point was taken every second.

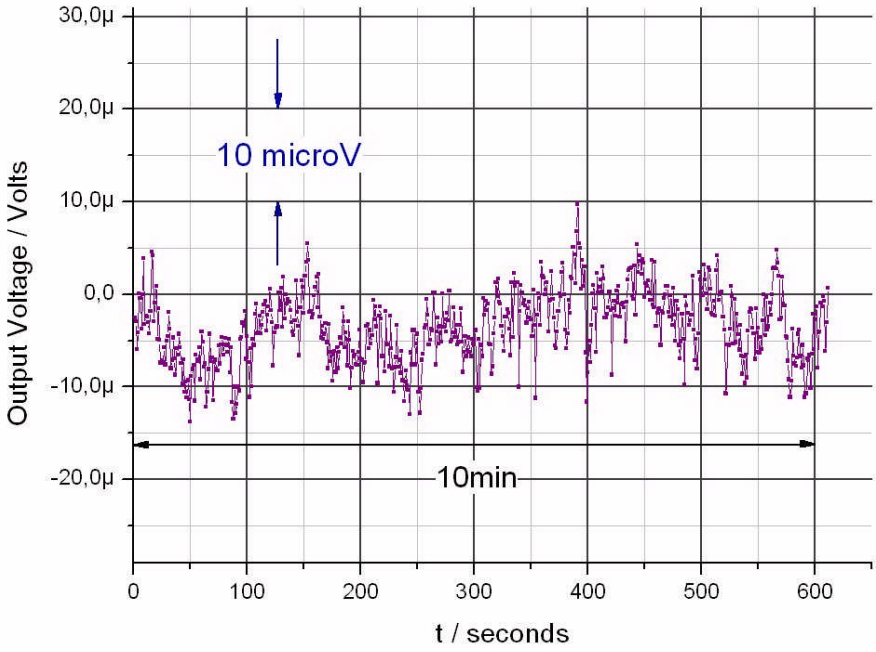


Fig. 9.4: The typical short term stability of an output channel at 0V is shown here. Measurement device was a Fluke 8846A multimeter, 0.5sec. averaging per data point. One measurement point was taken every second.

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Appendix

User-Defined Remote-Control and List of Commands

Introduction

The device can be controlled using the provided LabVIEW™ cource code blocks, or by self-written program code. Standard program compilers/interpreters like C++, BASIC or Pascal/Delphi dialects may be used for this purpose and also simple command-line terminal programs (e.g. HyperTerminal™) will do. The physical line connection to the device (USB-connection 1.0 protocol, but also 2.0 compatible) needs to be established beforehand, like described in section 3.2.1. USB-drivers for Windows™ versions, Mac OS and Linux are provided. Please check eventually the USB-manufacturers homepage (www.ftdichip.com) for latest updates.

Note that the physical communication acts like a so-called RS232 device, communicating with standard settings (9600 Baud, 8N1 protocol, no handshake) or with faster settings in fast-mode (115200 Baud, 8N1 protocol, no handshake), in case the device was ordered with the fast-mode option. If the fast-speed option is installed, the latter is marked with a label at the rear side USB socket. In self-written code the 115200 Baud rate parameter needs to be set accordingly, 9600 Baud otherwise. In Windows™ operating systems the device appears on a 'COM'-port, as soon as connected to the control PC (after driver installation). The COM-Port number is assigned by Windows upon connecting the device by USB cable and may change from time to time. The COM-Port settings may be checked by the user inside the Windows™ system control panel .

Command List

Inside this table the abbreviation "DDDDD" represents the name of the device including its serial number, e.g. "HV009" means a device with serial number "009". All commands must be terminated with an CR ('carriage-return') symbol "↵" (13 in ASCII code). First, after establishing the USB link to the HV device and turning it on, the IDN identifier should be sent in order to retrieve the serial number, since this serial number will be used to address the device correctly. See also examples and more details after the table.

Command Function	**ASCII Strings** sent to device or received + CR ('carriage-return') at string ends	**Observations and comments**
Identify device	sent IDN received DDDDD … … …	The device replies with its name, serial number (DDDDD) and further information. See also examples below this table.
Set voltage	sent DDDDD CHXX Y.YYYYYY received (normal mode) CHXX Y.YYYYYY received (fast mode) [ACK-Symbol]	An output voltage is set. XX is the adressed channel number (01 up to 16), Y.YYYYYY is a decimal number between 0.000000 and 1.000000 which represents the scaled voltage. I.e. 0.000000 represents the minimum voltage (e.g. -14V), 1.000000 the maximum value (e.g. +14V). 5 or 6 or 7 digits after the decimal point are required. In normal mode operation the command sent to the device is reflected (echoed) back. In fast mode operation the command sent to the device is not echoed back but only the acknowledge symbol (ASCII symbol 6) + CR

Query voltage and current	sent DDDDD QXX received +/-yy,yyy V +/- z,zzz mA	Requests read-back of internally measured voltage and current of channel XX. The return string contains voltage and current including dimensions (voltage/current units). Note that the real output values may be more precise and stable than the read-back values.
Read temperature	sent DDDDD TEMP received TEMP XXX.XºC	XXX.X is the temperature in degrees Celsius, measured at an internal temperature sensor. This value should be regularly checked (e.g. once per minute) while the device is in operation. Temperatures above approx. 55°C indicate a possible ventilation problem or other malfunction. The device should be switched of in this case to prevent serious damage or fire hazard
Check lock status of all channels	sent DDDDD LOCK received $B_3B_2B_1B_0$	Probes all channels to see if any is overloaded. The response is coded into 4 bytes (B_3 to B_0), see also definitions below. If a Bit is zero, then locking is ok, if = 1 then an overload occurred in the respective channel.
String to LCD-display	sent DDDDD DIS L “string” or DDDDD DIS L CHXX “string” received [ACK-Symbol]	Sends a “string” (arbitrary chain of ASCII characters, max. 16 characters long) to the front LCD display of the device. If a channel number XX is transmitted the string will be placed in the line of the corresponding channel XX. Otherwise the string will only be visible in the ‘Protocol Mode’ of the front display. Note that the provided LabVIEW source code uses this command to indicate the set voltages, since the ‘Set Voltage’ command only transmits a scaled voltage, which is not easily readable ASCII text.
Set correction parameters	sent DDDDD CORR …….. received CORR ……..	Change of correction parameter, in a dedicated LabVIEW control, or coded as shown below. For adjustment during manufacturing process and later re-adjustment only.

Further explanations and examples

Device identifier,
sent back from a device upon request by the “IDN” command:

The identifier string consists of several parts, returning information about the device. Every part is separated from the next by a normal “space”-character:
Example:
“HV023 5 16 b” = “HV” + “003” + “ 5” + “ 16” + “ b”
That means: a HV-series or BS-series device answers, serial number is 023, voltage range +/-5V, 16 channels, and having **b**ipolar outputs. This identifier string is programmed into the FlashRom of every HV / BS series device by factory.
The different string options are:

first string part:	always “HV”, also for BS devices
2nd part:	serial number between “001” and “999”
3rd part:	voltage in volts, can be any (integer) number between 1 and 100000
4th part:	number of channels, presently either “4” or “8” or “16”
5th part:	“b” like bipolar or “u” like unipolar “q” like quadrupole lens supply, “s” like steerer supply

Command Examples for setting a voltage:
Example a:
The command "HV014 CH02 0.00000" puts channel number 2 on minimum voltage, i.e. -10V for a device with +/-10V outputs (assuming the devices serial number is 014).

Example b:
The command "HV014 CH02 1.00000" puts channel number 2 on maximum voltage, i.e. +10V for a device with +/-10V outputs

Example c:

The command "HV014 CH02 0.50000" puts channel number 2 on half span between minimum and maximum, which is zero voltage.
All other voltages between "0.00000" and "1.00000" are scaled linearly, e.g. "0.75000" represents 75% of full span above minimum voltage, which is +2.5V for a +/-5V device.

The user is free to choose the number of digits sent after the decimal point from 5 to 7; however, for exploiting the devices internal resolution of 16 Bits (or higher in customized version) at least 6 digits should be used.

Coding of the 16 channels/bits into the control 4 bytes $B_3B_2B_1B_0$:
The following encoding is used for the "Check Lock" command.
The first 4 bits (= upper nibble) of every Byte is always 0001 = 16_{dec}. This is in order to avoid certain bit-combinations, which could cause trouble to USB/RS232-based communication (like "enter", "escape").
Next 4 bits (=lower nibble):

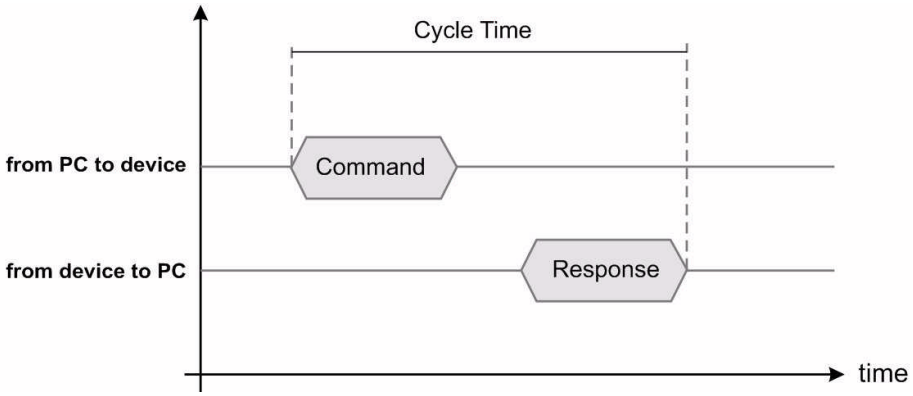
in B_3:	ch16	ch15	ch14	ch13
in B_2:	ch12	ch11	ch10	ch09
in B_1:	ch08	ch07	ch06	ch05
in B_0:	ch04	ch03	ch02	ch01

For instance B_0 = 0001 0011 means, that 3 and 4 are ok, 1 and 2 not locked (or overloaded).

Correction Command (advanced users only)
The correction command is primarily used within the manufacturing process and adjusts correction routines inside the HV or BS series devices. The format of the correction command looks like
"HV084 CORR02 0.12345 +0.54321",
which means that the device with serial number 084 is changed, specially channel number 2 in this case.
The span correction comes first (0.12345), then the offset correction (+0.54321). These both numbers represent the correction parameters. The span correction ranges from 0.00000 to 1.99999 (always 5 digits after the decimal point), and the offset correction ranges from -0.49999 up to +0.49999. For the offset the sign "-" or "+" always has to be sent as well. The decimal point always must be a point and not a comma (". " and not ","). Please contact manufactirer in case correction commands were sent in error, to retrieve the original factory settings.

Communication Speed

The device is shipped with one of two speed options installed. In the 'Normal Mode' the transmission speed of single bits is 9600 Baud (9600 raw-Bits per second), whereas in the 'Fast-Mode' transmission speed is 115200 Baud. In 'Normal Mode' the 'cycle time' (as illustrated in the sketch below, time period from start of any command sent to device until end of its answer) is about 35ms to 40ms.



The 'Fast-Mode' is rather optimized for quicker communication with the device (e.g. for biasing quantum transport experiments or STM/AFM setups), the cycle times for individual commands are therefor listed below.

Command	**Cycle Time, Fast-Mode**
Set voltage	2.36ms
Query	3.18ms
Check lock	1.68ms
String to LCD-display	3.56ms (16 characters sent)

Please note that the 'string to LCD display' command requires furthermore about 4.6ms more to indicate the string sent on the screen, after the device has already responded. It is therefore not recommended to use this command if maximum speed (about 300 commands per second) is relevant.

In order to avoid jamming of the data flow it is also recommended to wait for each command to be answered by an response (full cycle time, as indicated above) and not sending data *before* the response of the previous command has been completed.

DECLARATION OF CONFORMITY

Manufacturer's Name: **Dr. Stefan Stahl**
- Electronics for Science and Research -

Manufacturer's Address: **Kellerweg 23**
67582 Mettenheim
Germany.

Declares, that the product

Product Name: **BS series voltage supply**
Model Number: **BS 1-4, BS 1-8, BS 1-10, BS 1-16,**

Product Options: **This declaration covers all options of the above product(s)**

Conforms with the following European Directives:

The product herewith complies with the requirements of the:

1. Low Voltage Directive 73/73EEC;

2. EMC Directive 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly

Date of Issue _____

15. March 2014 **General Director**

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